King County
Brightwater
TREATMENT SYSTEM

BRIGHTWATER POST-CONSTRUCTION

Eelgrass Program:
2009 Eelgrass Dive Survey Report

Task 500

Subtask 560

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Rev 1

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Chapter 1
Introduction

As part of the Brightwater Treatment System, King County (County) completed construction of a new marine outfall in 2008, immediately south of Point Wells, Washington (Figure 1). Although the outfall was sited at Point Wells to minimize effects on nearshore marine areas, specifically native eelgrass (*Zostera marina*) beds, unavoidable impacts to eelgrass during the construction phase of this project occurred (King County 2003a, b). The County prepared an Eelgrass Restoration and Biological Resources Implementation Work Plan (Work Plan) that describes a multi-year eelgrass monitoring program for the Brightwater Outfall project (King County 2005). The eelgrass monitoring component of the Work Plan includes both dive-based density surveys and a combination of sonar and underwater video-based coverage surveys. The construction schedule called for pre-construction monitoring surveys to be conducted in 2004, 2006, and 2008 in order to establish baseline site conditions.

Disturbed areas of eelgrass within the Marine Outfall Corridor were restored in May 2009 by Grette Associates (King County 2009). As specified in the Work Plan (King County 2005), post-transplant monitoring of the Marine Outfall Corridor and Reference Area is required each year from 2009 through 2014 (with the exception of 2013). This report provides methods and results for the first post-transplant monitoring dive survey conducted September 22, 23, and 24, 2009.

1.1 Previous Eelgrass Surveys

Pre-construction dive surveys were conducted at the site using the methods described in detail in Chapter 2 of this document and in previous survey reports (e.g., King County 2006 & 2008). These surveys utilized 2 sets of transects spaced at 5-foot intervals with density measurements (triplicate counts) conducted every 10 feet in the Outfall Area and 20 feet at the Reference Area location (Figure 2). Also, in 2004 and again in 2008, the eelgrass within the entire Study Area (defined below) was mapped using Side-Scan sonar and roughly quantified using underwater videography (PNNL 2006). The results of those efforts are presented under separate cover.

During the final pre-construction (2008) diver survey in the Marine Outfall Corridor, eelgrass was observed above -15 ft MLLW and within 34 of 105 sample quadrats (32%). Density of eelgrass within the Outfall Corridor ranged from 1 to 227 shoots/m^2, with an average density of 80 shoots/m^2 where present. Within all sample quadrats including those where eelgrass was absent, eelgrass density in the Outfall Corridor averaged 26 shoots/m^2. Eelgrass shoot density at all elevations was greater in 2008 when compared to 2006, 2004 and 2003 survey data (King County 2008).

1.2 Survey Areas

For pre-construction monitoring, the Work Plan defines three specific monitoring areas at Point Wells: the Eelgrass Study Area (sonar and underwater video only), the Marine Outfall Corridor, and the Eelgrass Reference Area (Figure 2). Based on 2003 eelgrass distribution at this site (King County 2003b), all monitoring areas include elevations between approximately 0 ft MLLW and -25 ft MLLW. The diver surveys in 2004, 2006, 2008 and 2009 (described in this report) were conducted only in the Marine Outfall Corridor and the Eelgrass Reference Area. For clarification purposes, a description of the Eelgrass Study Area is also included.

The Eelgrass Study Area surrounds the proposed Outfall Alignment and is bounded from east to west by the upper and lower range of potential eelgrass habitat and from north to south by the area in which unanticipated impacts from construction, boats, and barges will be confined.

The Marine Outfall Corridor is within the greater Eelgrass Study Area. It is a 23-ft wide area centered along the outfall pipeline alignment, including allowances for the 12-ft wide sheeted trench area with an additional 5.5-ft wide area on either side of the sheeted trench to account for potential localized effects of construction (i.e., driving sheet pile walls, excavating material with a clamshell dredge, backfilling, etc…).

The Eelgrass Reference Area is approximately 332 ft SSE of the Marine Outfall Corridor, well outside of the area in which construction impacts are anticipated.

1.3 Dive Survey Monitoring Schedule

A total of three pre-construction dive surveys were conducted in the Outfall Corridor and Reference areas in 2004, 2006, and 2008 (Table 1) as directed by the Work Plan. The 2009 monitoring effort is the first post-transplant survey. In addition to required dive surveys, the Work Plan also calls for sonar and video surveys of the site; results of these surveys are reported under a separate cover.

Table 1. Dive Survey Monitoring Schedule.

Year, Season	Eelgrass Post-Transplant Monitoring Year	Survey Areas	Survey Purpose
2004, Summer	Year -5	Marine Outfall Corridor, Reference Area	Establish baseline and variation
2006, Summer	Year -3	Marine Outfall Corridor, Reference Area	Establish variation
2008, Spring	Year -1	Marine Outfall Corridor, Reference Area	Establish variation
2009, Summer	Year 0*	Marine Outfall Corridor, Reference Area	Transplant monitoring
2010, Summer	Year 1	Marine Outfall Corridor, Reference Area	Transplant monitoring
2011, Summer	Year 2	Marine Outfall Corridor, Reference Area	Transplant monitoring
2012, Summer	Year 3	Marine Outfall Corridor, Reference Area	Transplant monitoring
2014, Summer	Year 5	Marine Outfall Corridor, Reference Area	Transplant monitoring

*Year 0 indicates the transplanting of eelgrass

Chapter 2
Methods

Pre-construction eelgrass density monitoring occurred in two survey areas: the Marine Outfall Corridor and the Eelgrass Reference Area. Five transects were defined ahead of time in each area, and end point coordinates were identified on base maps. Transects 1, 3, and 5 at the Marine Outfall Corridor were defined using the shallow endpoints for the three center transects from the 2003 eelgrass diver survey (King County 2003b). For both survey areas, transects were spaced 5 ft apart (Figures 3 and 5). As noted in previous reports, permanent rebar stakes were place at the shoreward and waterward endpoints of both sets of transects in 2004. Also in 2004, additional rebar stakes were placed in the interior every 50 ft (Corridor) and 40 ft (Reference Area), to assist in tape placement during transect surveys. Prior to construction of the Outfall, the 50 ft, 100 ft, and 150 ft stakes were removed from the Outfall Corridor; following construction, stakes were placed every 40 ft (and labeled on the caps) to aid ROV guidance during future video surveys. The stakes in the Reference Area remained as originally placed (every 40 ft).

2.1 Identification of Survey Areas

During the 2009 survey, a dGPS was used to relocate shallow end points marked by rebar stakes at both the Marine Outfall Corridor and the Eelgrass Reference Area. Transect tapes were deployed from these markers and extended to the deep end point markers. All rebar stakes were located in the Marine Outfall Corridor and the majority of rebar stakes were located in the Eelgrass Reference Area. In instances where a rebar stake was not located, a compass bearing was used to find the next rebar (40 ft beyond the missing stake) and the transect line continued. Missing/non-located rebar markers were replaced once transects were established.

Table 2. Transect End and Reference Point Coordinates (NAD 83).

Area, Transect, Point	Northing	Easting
WDNR Survey Monument 1	287663.56	1256628.75
WDNR Survey Monument 2	287662.59	1256670.75
Marine Outfall, 1, onshore	288247.63	1255853.58
Marine Outfall, 5, onshore	288227.55	1255854.88
Marine Outfall, 1, offshore	288218.42	1255671.01
Marine Outfall, 5, offshore	288197.56	1255667.62
Eelgrass Reference, 1, onshore	287924.36	1255927.13
Eelgrass Reference, 5, onshore	287905.71	1255937.91
Eelgrass Reference, 1, 200-ft midpoint	287863.86	1255505.96
Eelgrass Reference, 5, 200-ft midpoint	287842.75	1255498.97
Eelgrass Reference, 1, offshore	287863.86	1255729.16
Eelgrass Reference, 5, offshore	287877.26	1255739.94

2.2 Survey Methods

The eelgrass survey methods are based on 2003-2007 Washington Department of Fish and Wildlife (WDFW) Eelgrass/Macroalgae Habitat Survey Guidelines. At each sample location, divers recorded triplicate shoot counts within a 0.25-m^2 quadrat rotated around the sample location to the 2, 6, and 10 o'clock positions (relative to waterward orientation on the survey tape). The inside corner of the quadrat pivoted around the same center point to ensure repeatability. This center point was the pre-determined distance measured on a fiberglass survey tape stretched between permanent markers, in sample intervals specific to each survey area.

Divers stretched a fiberglass survey tape along each transect, based on endpoint rebar stakes and interior stakes. Triplicate shoot counts were recorded at 10-ft intervals in the Marine Outfall Corridor and at 20-ft intervals in the Eelgrass Reference Area. Qualitative observations of macroalga species presence and distribution as well as qualitative notes on substrate type were recorded within each sample quadrat. In addition, divers noted eelgrass patch edges along each transect (e.g., begin at 25 ft, end at 32 ft; begin at 54 ft, end at 67 ft) for each of the 10 transects. At the Marine Outfall Corridor, a total of 21 sample locations were recorded along each transect, for a total of 105 samples. At the Eelgrass Reference Area, a total of 22 sample locations were recorded along each transect, for a total of 110 samples. Starting with the 2006 survey, an additional 2 sample points were added to the Reference Area transects, bringing the total length to 460 ft, and ending at a final depth of -25 ft MLLW (to correspond to the final depth of the Marine Outfall Corridor). In 2009, visual observation by divers of this area confirmed the absence of any eelgrass plants.

2.3 Density Calculations

Eelgrass shoot density for each sample, reported as the number of eelgrass shoots per square meter, is calculated from the mean of the triplicate shoot count at the sample location multiplied by four (since the quadrats are 0.25 m^2). The 2003-2007 WDFW method for density calculations requires that samples that were taken where eelgrass is present are included in density calculations for either survey area (i.e., a sample where all three triplicates have a shoot count of zero is not included).

Chapter 3
Survey Results

3.1 Marine Outfall Corridor

3.1.1 Density of transplanted bands

In the last pre-construction survey completed in 2008, eelgrass was found within the Corridor between approximately -2 and -12 ft MLLW (Grette Associates 2008). Within this area of the Corridor, two "bands" of notable eelgrass density were observed: band A was located within the 0 to -5 ft MLLW contours (between 50 and 70 ft on the Outfall Corridor transects); band B was located roughly within the -5 to -15 ft MLLW contours (between 100 and 140 ft on the Outfall Corridor transects). Sparse eelgrass was observed between the two bands. The location of each band in relation to the transects is depicted in Figures 3 and 4.

In May of 2009, eelgrass was planted within the Outfall Corridor according to the Work Plan guidelines (Photographs 1-3). Eelgrass was planted at densities greater than those noted during pre-construction surveys in order to maximize the likelihood of transplant success. Plants were placed in two distinct bands (A and B) as noted in the transplant report (King County 2009). The number of plants placed into the Corridor was approximated to be between 10,000 and 16,000.

During the September 2009 survey, one eelgrass band was observed to span all 5 transects from 50-70 ft (between 0 ft and -5 ft MLLW) and a second band was observed between 100-140 ft (between -5 ft and -12 ft MLLW), corresponding closely to the 2 bands planted in May (Figure 4). The density of band A in September was 151 shoots/m^2, and the density of band B was 82 shoots/m^2. As expected, both bands exhibited a higher density than the pre-construction 2008 values due to intentional over-planting (King County 2009). Eelgrass plants also appeared in the area between the bands on Transect 5, an area that had not been planted in the May effort (Figure 4). These plants were associated with an existing eelgrass bed to the south of the Corridor, having been captured on the edge of Transect 5 during the September survey.

3.1.2 Overall eelgrass density

In the Marine Outfall Corridor, 42 of the 105 samples (40%) included eelgrass (Table 3). Where present, average eelgrass density in this area was 107 shoots/m^2. Individual density measurements ranged from 1 to 237 shoots/m^2 (Figure 3). Across all sample points, including those where eelgrass was not present, eelgrass density in the outfall corridor was 43 shoots/m^2. As in previous years, eelgrass was present only above -15 ft MLLW. The greatest eelgrass density by elevation was 143 shoots/m^2 between 0 and -5 ft MLLW; greatest coverage (100% of sampled locations) occurred between -5 and -10 ft MLLW (Table 3). (Please note that the density by elevation statistics for the Outfall Corridor are reported in Table 3 for continuity with previous reports, but due to the May 2009 transplant, these values do not reflect eelgrass

coverage trends per se). No rooted eelgrass was observed in the debris mat at the toe of the slope in the Marine Outfall Corridor.

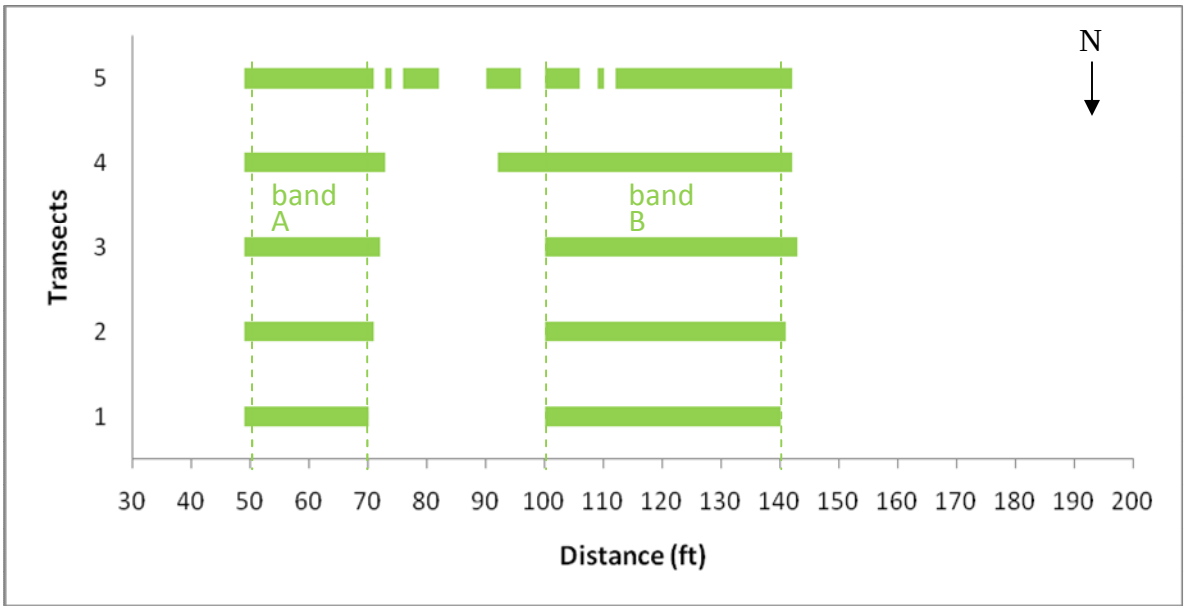


Figure 4. Eelgrass Edge Locations in the Outfall Corridor, September 2009. For clarity, the shallowest portion of the transects (0-20 ft distance), where no eelgrass was present, is not displayed on the figure. Bands A and B denote areas transplanted in May of 2009.

3.1.3 Substrate and macroalga cover

Patterns of substrate composition and alga coverage were similar on all 5 survey transects (Appendix A). Substrate was generally sandy for the extent of each transect, with some gravel and cobble interspersed. The greatest diversity of macroalga coverage (which was primarily comprised of *Ulva* spp.) correlated to coarser substrates and shallower elevations, although there were also areas of macroalga cover in deeper, sandy substrates. Macroalgae presence in the Marine Outfall Corridor is presented in Table 4.

3.2 Eelgrass Reference Area

3.2.1 Eelgrass density

In the Eelgrass Reference Area, 60 of the 110 samples (54%) included eelgrass (Figure 5). Where present, average eelgrass density in this Reference Area was 156 shoots/m^2 (Table 3). Across all sample points, including those where eelgrass was not present, eelgrass density in the outfall corridor was 78 shoots/m^2. Individual density measurements ranged from 3 to 868 shoots/m^2. Eelgrass was present between 120 ft and 380 ft on the transects (Figures 5 and 6). Greatest eelgrass density (where present) by elevation was 398 shoots/m^2 between 0 and -5 ft MLLW; greatest coverage (93% of sampled locations) occurred between -10 and -15 ft

MLLW (Table 3). Eelgrass appeared to form two patches of high density, one within the 100 to 140 ft transect distance, and a second within the 160 and 390 ft transect distance for all transects save Transect 5, in which sparse eelgrass was also observed between the two patches (Figure 6). Similarly to 2008, eelgrass density tended to decrease between 240 and 300 ft along the transects, in correlation with increased macroalgae coverage. This is also an area where bathymetry changes quickly between -10 and -15 MLLW, before flattening out between -15 and -20 MLLW. The Reference Area eelgrass patch ended between 380 and 400 ft along the survey transects, above -20 ft MLLW.

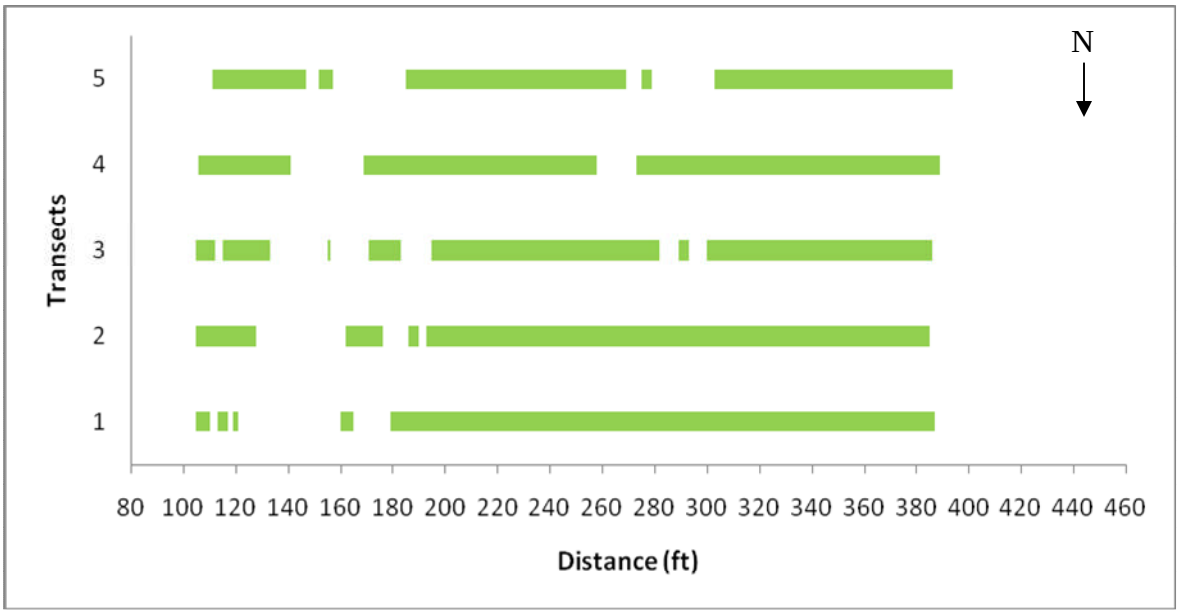


Figure 6. Eelgrass Edge Locations in the Reference Area, September 2009. For clarity, the shallowest portion of the transects (0-70 ft distance), where no eelgrass was present, is not displayed on the figure.

3.2.2 Substrate and macroalga cover

Similar to the Marine Outfall Corridor, substrate in the Reference Area was generally coarser above -5 ft MLLW and was similar in composition along all five transects, starting with cobble and gravel substrates at the shallow end and transitioning to mostly sandy substrate beyond 80 ft (Appendix A). Some coarser substrate was also evident as far as 280 ft along transect 5 (Appendix A). Macroalgae species were most likely to be observed in areas of coarse substrate in the shallow end of the survey area, as well as on the slope or its toe between -10 and -15 ft MLLW (Table 4). Macroalga composition in this area included large blades of *Saccharina latissima* (formerly *Laminaria* spp.) and a diverse assemblage of smaller species. *Ulva* and *Gracilaria* spp. were also observed at all 5 depth bins within the Reference Area (Table 4). Beyond approximately 380 ft along the survey transects, macroalga cover consisted of sparse single *S. latissima* blades with occasional other small taxa (Appendix A).

Table 3. 2009 Eelgrass observations by elevation at each survey area.

	Marine Outfall Corridor				Eelgrass Reference Area			
Elevation (ft below MLLW)	**Average shoots/m^2 eelgrass***	**n***	**Average shoots/m^2 entire sample****	**Samples****	**Average shoots/m^2 eelgrass***	**n***	**Average shoots/m^2 entire sample****	**Samples****
0 – 5	143	17	49	50	398	5	57	35
5 – 10	90	20	90	20	288	17	196	25
10 – 15	50	5	25	10	91	13	85	14
15 – 20	0	0	0	6	52	25	42	31
20 – 25	0	0	0	19	0	0	0	5
>25	--	--	--	--	--[†]	--[†]	--[†]	0[†]
All	107	42	43	105	156	60	78	110

* Based on observations with eelgrass (each observation is a density based on triplicate shoot counts)
** Based on all observations made at each elevation
[†]This section of the Reference Area transects was not surveyed in 2009

Table 4. 2009 Macroalgae species observed at each survey area.

Elevation (ft below MLLW)	Marine Outfall Corridor			Reference Area		
	Species	**n***	**Samples****	**Species**	**n***	**Samples****
0 – 5	*Ulva* spp.	33	50	*Ulva* spp.	23	35
	Chondracanthus spp.	2		*Chondracanthus* spp.	8	
	Saccharina latissima††	3		Coralline algae	1	
	Porphyra spp.	2		*Gracilaria* spp.	3	
	Prionitis spp.	3		*Mazzaella splendens*	2	
	Pterothamnion spp.	1		*Saccharina latissima*††	1	
	Sargassum muticum	1		*Porphyra* spp.	1	
				Prionitis spp.	1	
				Unknown spp.	1	
5 – 10	*Ulva* spp.	19	20	*Ulva* spp.	11	25
	Porphyra spp.	2		*Gracilaria* spp.	2	
	Saccharina latissima††	11		*Saccharina latissima*††	1	
				Prionitis spp.	1	
				Smithora naiadium†	2	
10 – 15	*Ulva* spp.	5	10	*Ulva* spp.	12	14
	Costaria costata	1		*Ceramium* spp.	1	
	Gracilariopsis spp.	1		Coralline algae	1	
	Saccharina latissima††	3		*Gracilaria* spp.	9	
				Saccharina latissima††	6	
				Mazzaella splendens	3	
				Porphyra spp.	3	
				Prionitis spp.	8	
				Pterothamnion spp.	1	
				Smithora naiadium†	5	
15 – 20	*Ulva* spp.	4	6	*Ulva* spp.	22	31
	Gracilariopsis spp.	1		*Ceramium* spp.	2	
	Saccharina latissima††	2		*Chondracanthus* spp.	2	
				Fauchea spp.	2	
				Gracilaria spp.	10	
				Gracilariopsis spp.	3	
				Saccharina latissima††	14	
				Mazzaella splendens	3	
				Margarites pupillus	1	
				Porphyra spp.	2	
				Prionitis spp.	5	
				Pterothamnion spp.	6	
				Smithora naiadium†	3	

Elevation (ft below MLLW)	Marine Outfall Corridor			Reference Area		
	Species	**n***	**Samples****	**Species**	**n***	**Samples****
20 – 25	*Ulva* spp.	9	**19**	*Gracilaria* spp.	2	**5**
	Saccharina latissima[††]	5		*Saccharina latissima*[††]	1	
	Margarites pupillus	1				
>25	not sampled			not sampled		
All		79	105		80	110

[†] Observed on eelgrass or *Ulva* spp.
[††] Formerly *Laminaria* spp.
* Number of sampling locations where each species was observed
** Total number of observations made at each elevation

Chapter 4
Discussion

The 2009 eelgrass survey was completed only 4 months after the May 2009 transplant efforts; in May, eelgrass had been intentionally planted at a density greater than that observed pre-construction (King County 2009) to ensure adequate restoration of the Marine Outfall Corridor. Due to the short time period between transplant and survey, a large difference in eelgrass density was neither expected nor observed within the transplanted Corridor; bands A and B remained in the approximate size and shape as they had been planted. The planted eelgrass did exhibit evidence of considerable growth during the four month period, and no loss of plants or decrease in patch density was observed. Blade length of all plants appeared to have increased over the 4 months, though no direct measurements were made (Photographs 1-3).

Density of eelgrass shoots in the Reference Area increased dramatically in 2009 compared to values reported in 2008 (Table 5). An approximately 4-fold increase in density was observed at the 0 to -5, -5 to -10, and -10 to -15 depth bins over the course of 1 year. A two-fold increase in density was observed within the -15 to -20 depth bin. The number of samples with eelgrass did not change greatly from 2008 to 2009, implying that the eelgrass beds grew more densely, but did not necessarily expand in area.

The elevation range at which eelgrass was observed in 2009 remained similar to that observed in previous years at both study sites (Table 5). As in 2006 and 2008, no plants were observed at depths greater than -15 ft MLLW in the Outfall Corridor during the 2009 survey, which was expected since no shoots were planted at a depth greater than approximately -12 ft MLLW.

In Puget Sound, eelgrass typically becomes light limited at around -7 m relative to Mean Sea Level (MSL) (Thom et al. 1999), which is approximately -13.5 ft MLLW based on 9.47 ft MSL at Edmonds. A number of other factors, including substrate, current, water quality and light transmission, contribute to the survival of eelgrass. These conditions may affect local differences in eelgrass plant density as well as differences observed at sites throughout Puget Sound. Inter-annual variation in site conditions, including light availability, water temperature, and nutrients may have resulted in favorable growing conditions and may have influenced the increased densities observed at the Reference Area compared to previous years.

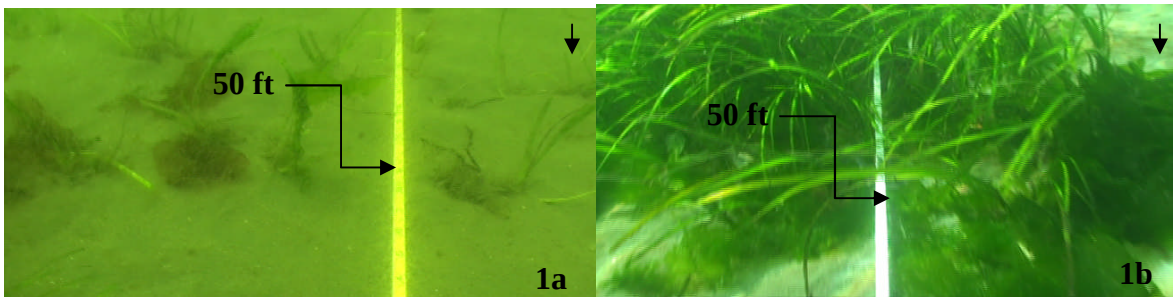
Table 5. 2004, 2006, 2008 and 2009 Eelgrass observations by elevation at each survey area.

	Marine Outfall Corridor		Eelgrass Reference Area	
Elevation (ft below MLLW)	**Average shoots/m^2**	**n***	**Average shoots/m^2**	**n***
2004				
0 – 5	26	9	18	3
5 – 10	29	10	52	11
10 – 15	20	4	29	12
15 – 20	3	1	23	24
20 – 25	7	4	0	0
All	23	28	30	50
2006				
0 – 5	63	9	62	4
5 – 10	59	14	91	11
10 – 15	33	5	35	12
15 – 20	0	0	35	24
20 – 25	0	0	0	0
>25	--	--	0	0
All	55	28	30	50
2008				
0 – 5	73	12	84	3
5 – 10	108	16	68	14
10 – 15	24	5	25	14
15 – 20	0	0	22	24
20 – 25	0	0	0	0
>25	--	--	0	0
All	80	33	38	55
2009				
0 – 5	143	17	398	5
5 – 10	90	20	288	17
10 – 15	50	5	91	13
15 – 20	0	0	52	25
20 – 25	0	0	0	0
>25	--	--	--**	--**
All	107	42	156	60

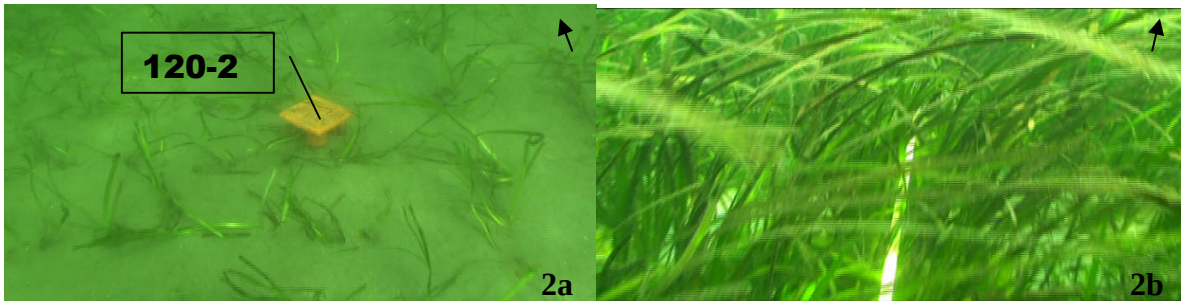
* Number of observations with eelgrass (each observation is a density based on triplicate shoot counts)
**This section of the Reference Area transects was not surveyed in 2009

4.1 Photographs

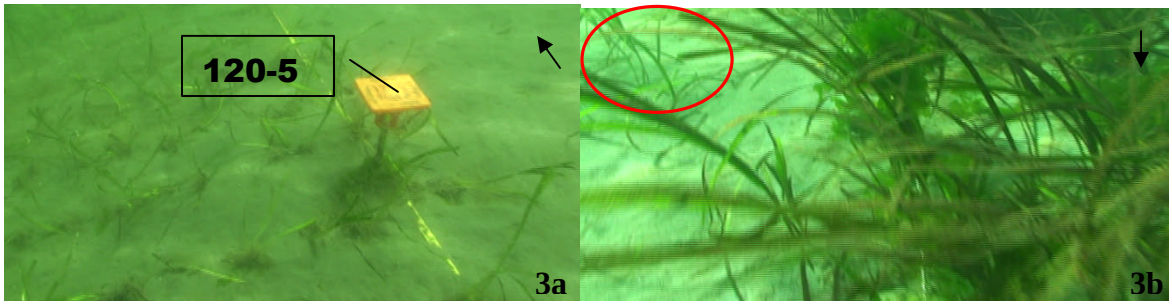
The following photographs, captured from stills of underwater video, were taken by divers within the Marine Outfall Corridor immediately after the May 2009 transplant and during the September 2009 survey.



Photographs 1a and 1b. A comparison of eelgrass planted in May 2009 (1a) and the same portion of the Outfall Corridor in September 2009 (1b). The area photographed is at 50 feet from the start of Transect 1, at the north edge of band A. The black arrows point shoreward. Because the spacing of transect tapes varied with wave action, one line of plants was placed to the north side of Transect 1 (right, in the photographs) to ensure full coverage of the 20-ft Corridor width.



Photographs 2a and 2b. A comparison of eelgrass planted in May 2009 (2a) and approximately the same portion of the Outfall Corridor in September 2009 (2b). The area photographed is at 120 feet from the start of Transect 2, within the middle of band B. In photograph 2b, the 120-2 rebar cap is beneath the photographer. The black arrows point shoreward.



Photographs 3a and 3b. A comparison of eelgrass planted in May 2009 (3a) and approximately the same portion of the Outfall Corridor in September 2009 (3b). The area photographed is at 120 feet from the start of Transect 5, at the south border of band B. In Photograph 3b, the 120-5 rebar cap is beneath the photographer. The black arrows point shoreward. The red circle denotes volunteer eelgrass plants (in an area not planted in May) to the south of the Corridor.

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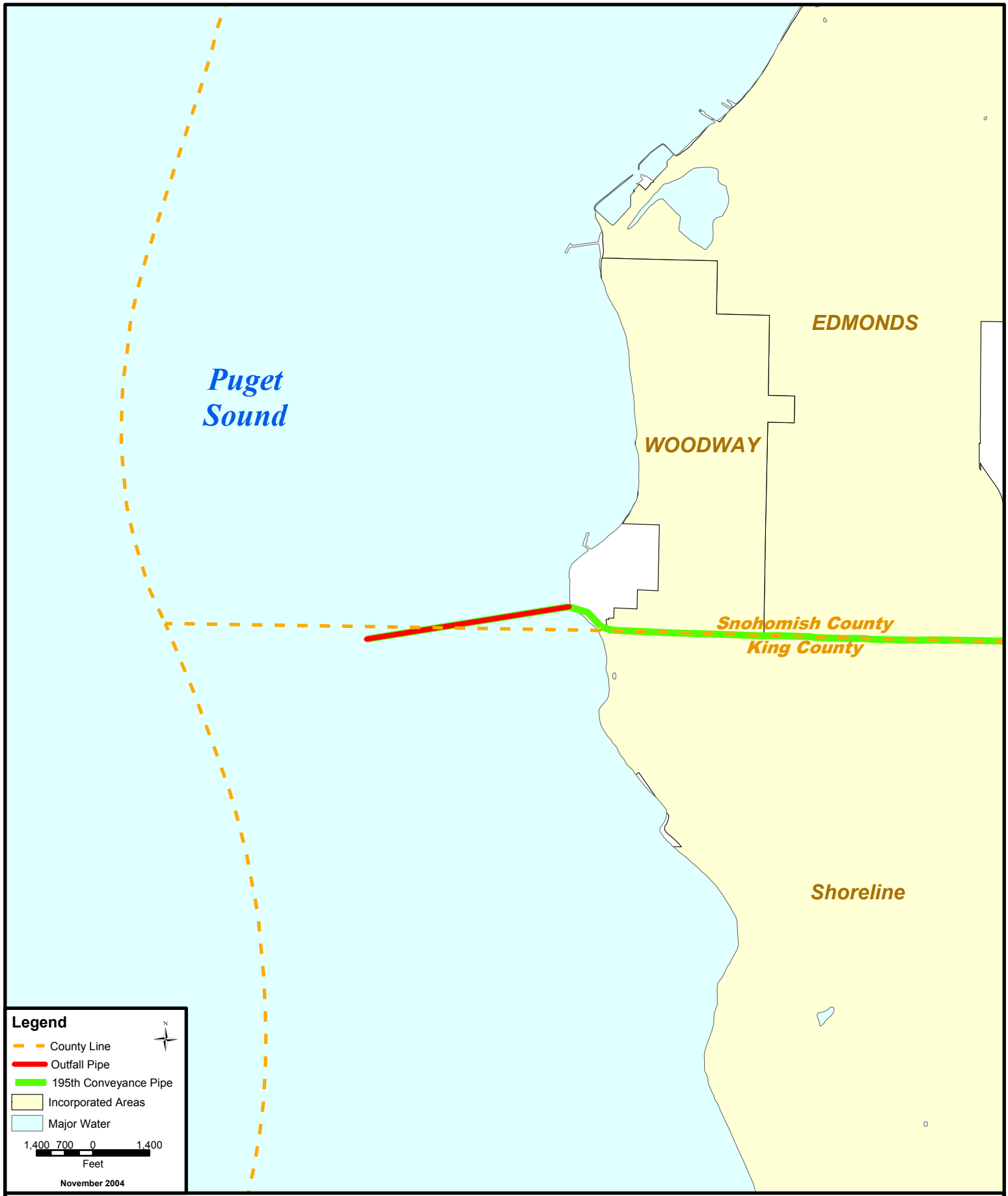

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Wastewater Treatment Division

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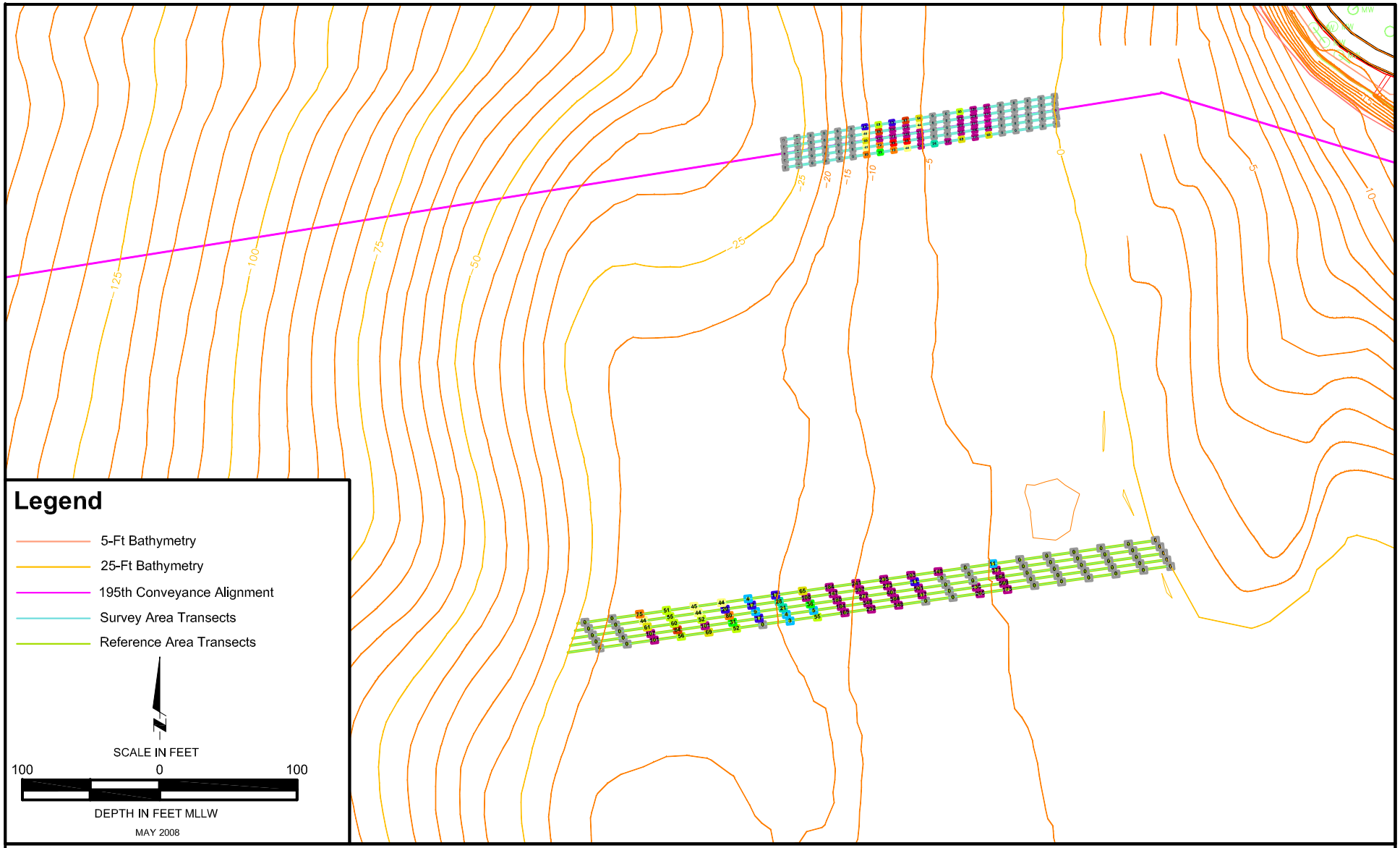
File Name: Q:\WTD\Projects\MOSS\Projects\outfall_vicinity.mxd SC

Figure 1

Marine Outfall Location

BRIGHTWATER REGIONAL WASTEWATER TREATMENT SYSTEM



King County
Department of Natural Resources and Parks
Wastewater Treatment Division

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File Name: 500-560-2
Prepared By: Grette Associates, LLC

FIGURE 2

Marine Outfall Site
Survey and Reference Areas

band B

band A

T1 0 0 0 0 0 0 12 55 15 87 64 0 0 60 151 127 0 0 0 0 0 0 T1

T2 0 0 0 0 0 0 48 88 104 133 44 0 0 172 228 171 0 0 0 0 0 0 T2

T3 0 0 0 0 0 0 69 121 112 120 111 0 0 237 211 107 0 0 0 0 0 0 T3

T4 0 0 0 0 0 0 41 72 99 99 183 0 0 137 196 205 0 0 0 0 0 0 T4

T5 0 0 0 0 0 0 80 39 72 44 147 24 141 65 131 69 0 0 0 0 0 0 T5

TRANSECTS

-25 -20 -15 -10 -5

Legend

Mean Eelgrass Density (Shoots per Meter Sq)

- 0
- 1 - 10
- 11 - 20
- 21 - 30
- 31 - 40
- 41 - 50
- 51 - 60
- 61 - 70
- 71 - 80
- 81 - 90
- 91 - 100
- 101+

Survey Plot (1-m²)

SCALE IN FEET

10 0 10

DEPTH IN FEET MLLW

SURVEY TRANSECTS

OUTFALL ALIGNMENT

October 2009

King County

Department of Natural Resources and Parks

Wastewater Treatment Division

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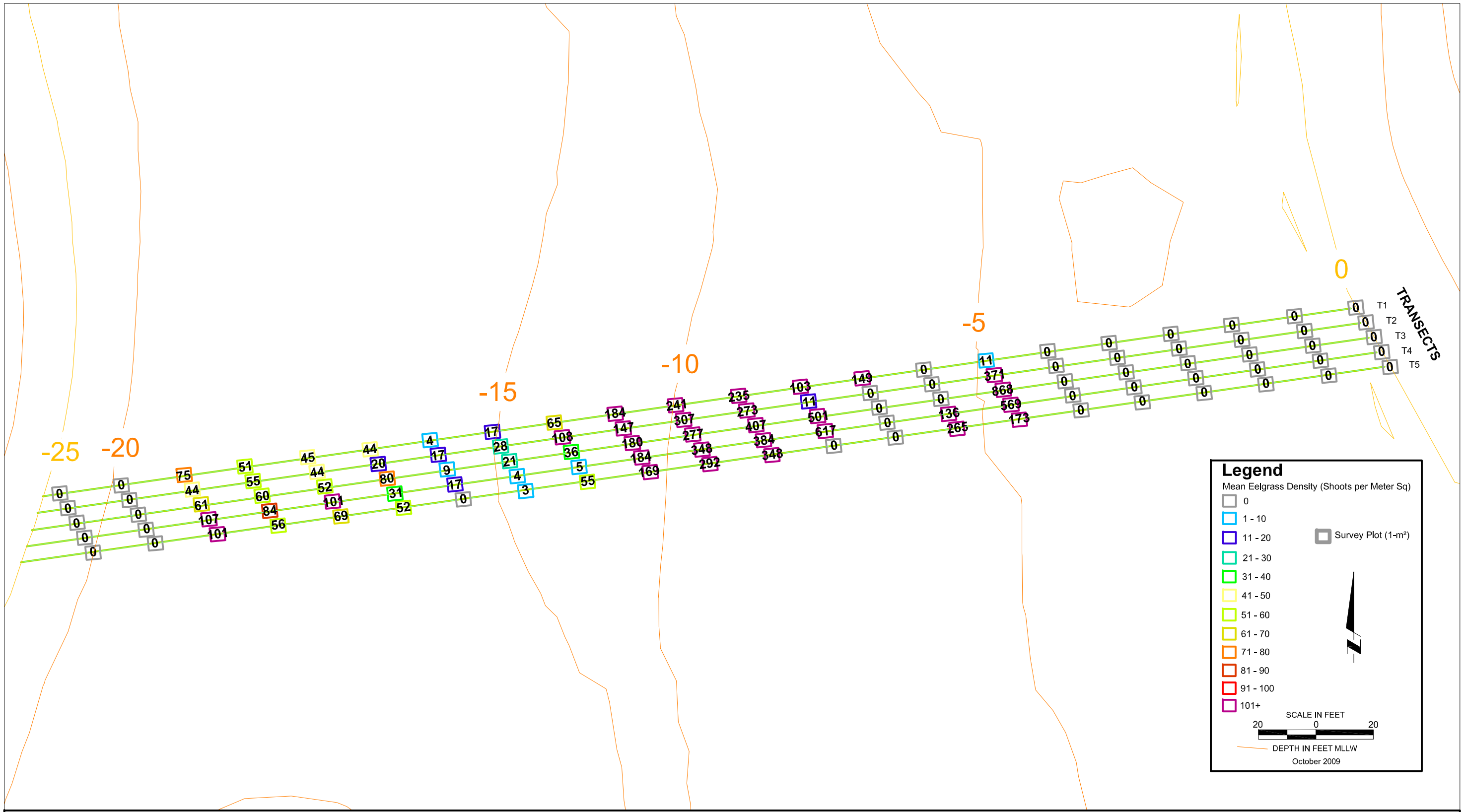
File Name: 500-560-3

Prepared By: Grette Associates, LLC

FIGURE 3

MARINE OUTFALL CORRIDOR EELGRASS DENSITY 2009 DATA



King County
Department of Natural Resources and Parks
Wastewater Treatment Division

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File Name: 500-560-5
Prepared By: Grette Associates, LLC

FIGURE 5

REFERENCE AREA EELGRASS DENSITY
2009 DATA

Appendix A

Brightwater Eelgrass Survey Data Table 2009

Table Legend

Transect:
- SA; Study Area
- RA; Reference Area

Depth Bin:
- 1; 0 to -5 ft MLLW
- 2; -5 to -10 ft MLLW
- 3; -10 to -15 ft MLLW
- 4; -15 to -20 ft MLLW
- 5; -20 to -25 ft MLLW

Substrate (qualitative):
- co; cobble
- gr; gravel
- sa; sand
- sh; shell hash

Eelgrass edge:
- b, e; begin, end

Macroalgae Taxa:

ce	*Ceramium* spp.
ch	*Chondracanthus exasperatus*
cl	*Cladophora sericea*
co	Coralline algae
cos	*Costaria costata*
de	*Desmarestia ligulata*
fa	*Fauchea* spp.
pt	*Pterothamnion* spp.
gr	*Gracilaria* spp.
grp	*Gracilariopsis* spp.
la	*Saccharina latissima**
ma	*Mazzaella splendens*
mr	*Margarites pupillus*
po	*Porphyra perforata*
pr	*Prionitis lanceolata*
sa	*Sargassum muticum*
sm	*Smithora naiadium*
ul	*Ulva* spp.
unk	unknown spp.

*Formerly *Laminaria saccharina*

Year	Transect	Distance (ft)	Depth Bin	Shoots/(0.25) m^2 2	6	10	Density (m^2)	Macro taxa	Substrate	Eelgrass edge	Notes
2009	SA-1	0	1	0	0	0	0.00	ul	sa, gr, co		
2009	SA-1	10	1	0	0	0	0.00		sa		
2009	SA-1	20	1	0	0	0	0.00	ul	sa		
2009	SA-1	30	1	0	0	0	0.00	ul, la	sa, gr, co		
2009	SA-1	40	1	0	0	0	0.00	ul	sa		
2009	SA-1	50	1	32	11	52	126.67	ul	sa	b 49, e 70	
2009	SA-1	60	1	16	38	59	150.67	ul	sa		
2009	SA-1	70	1	0	31	14	60.00	ul	sa		
2009	SA-1	80	1	0	0	0	0.00		sa		
2009	SA-1	90	1	0	0	0	0.00	ul	sa, gr		
2009	SA-1	100	2	18	0	30	64.00	ul, po	sa, gr	b 100, e 140	
2009	SA-1	110	2	6	25	34	86.67	ul, la, po	sa, gr		
2009	SA-1	120	2	0	0	11	14.67	ul, la	sa		
2009	SA-1	130	2	0	13	28	54.67	ul, la	sa, gr		
2009	SA-1	140	3	0	8	1	12.00	ul	sa		
2009	SA-1	150	3	0	0	0	0.00		sa, gr		
2009	SA-1	160	4	0	0	0	0.00	ul, la, grp	sa		
2009	SA-1	170	5	0	0	0	0.00	la	sa, gr		
2009	SA-1	180	5	0	0	0	0.00	la	sa, gr		
2009	SA-1	190	5	0	0	0	0.00		sa		
2009	SA-1	200	5	0	0	0	0.00	la, ul, mr	sa, gr		
2009	SA-2	0	1	0	0	0	0.00	ul, ch	sa, co		
2009	SA-2	10	1	0	0	0	0.00		sa		
2009	SA-2	20	1	0	0	0	0.00		sa		
2009	SA-2	30	1	0	0	0	0.00		sa		
2009	SA-2	40	1	0	0	0	0.00	ul	sa		
2009	SA-2	50	1	63	4	61	170.67	ul	sa	b 49, e 71	
2009	SA-2	60	1	49	69	53	228.00	ul, sa	sa		
2009	SA-2	70	1	37	36	56	172.00	ul	sa		
2009	SA-2	80	1	0	0	0	0.00	ul	sa		
2009	SA-2	90	1	0	0	0	0.00		sa		
2009	SA-2	100	2	16	0	17	44.00	ul, la	sa, co, sh	b100, e 141	
2009	SA-2	110	2	42	22	36	133.33	ul, la	sa, co		
2009	SA-2	120	2	26	30	22	104.00	ul	sa		
2009	SA-2	130	2	29	20	17	88.00	ul, la	sa		
2009	SA-2	140	3	12	8	16	48.00	la, ul	sa		

Year	Transect	Distance (ft)	Depth Bin	Shoots/(0.25) m^2 2	6	10	Density (m^2)	Macro taxa	Substrate	Eelgrass edge	Notes
2009	SA-2	150	3	0	0	0	0.00		sa		
2009	SA-2	160	4	0	0	0	0.00	ul	sa		
2009	SA-2	170	5	0	0	0	0.00	ul	sa, sh		
2009	SA-2	180	5	0	0	0	0.00	la	sa, sh		
2009	SA-2	190	5	0	0	0	0.00		sa		
2009	SA-2	200	5	0	0	0	0.00	ul, la	sa		
2009	SA-3	0	1	0	0	0	0.00	ul	sa, co		
2009	SA-3	10	1	0	0	0	0.00		sa		
2009	SA-3	20	1	0	0	0	0.00		sa		
2009	SA-3	30	1	0	0	0	0.00		sa		
2009	SA-3	40	1	0	0	0	0.00	ul, la	sa, co	b 49, e 72	
2009	SA-3	50	1	27	9	44	106.67	ul	sa		
2009	SA-3	60	1	56	58	44	210.67	ul	sa		
2009	SA-3	70	1	67	57	54	237.33	ul	sa		
2009	SA-3	80	1	0	0	0	0.00	ul	sa		
2009	SA-3	90	1	0	0	0	0.00		sa		
2009	SA-3	100	2	28	3	52	110.67	ul, la	sa	b 100, e 143	
2009	SA-3	110	2	15	26	49	120.00	ul	sa		
2009	SA-3	120	2	16	24	44	112.00	ul, la	sa		
2009	SA-3	130	2	25	43	23	121.33	ul, la	sa		
2009	SA-3	140	3	17	18	17	69.33	ul	sa		
2009	SA-3	150	3	0	0	0	0.00	ul, la, grp	sa		
2009	SA-3	160	4	0	0	0	0.00	ul	sa		
2009	SA-3	170	5	0	0	0	0.00	ul	sa, co		
2009	SA-3	180	5	0	0	0	0.00	ul	sa, co		
2009	SA-3	190	5	0	0	0	0.00	ul	sa		drift pile of loose macro
2009	SA-3	200	5	0	0	0	0.00	ul	sa		
2009	SA-4	0	1	0	0	0	0.00	ul	sa, co		
2009	SA-4	10	1	0	0	0	0.00	ul	sa		
2009	SA-4	20	1	0	0	0	0.00		sa		
2009	SA-4	30	1	0	0	0	0.00		sa		
2009	SA-4	40	1	0	0	0	0.00		sa, co		
2009	SA-4	50	1	85	51	18	205.33	ul	sa	b 49, e 73	
2009	SA-4	60	1	40	75	32	196.00	ul	sa		
2009	SA-4	70	1	33	25	45	137.33	ul, pr	sa		
2009	SA-4	80	1	0	0	0	0.00		sa		

Year	Transect	Distance (ft)	Depth Bin	Shoots/(0.25) m^2 2	6	10	Density (m^2)	Macro taxa	Substrate	Eelgrass edge	Notes
2009	SA-4	90	1	0	0	0	0.00		sa	b 92, e 142	
2009	SA-4	100	2	11	54	72	182.67	ul	sa		
2009	SA-4	110	2	26	24	24	98.67	ul, la	sa		
2009	SA-4	120	2	18	26	30	98.67	ul, la	sa		
2009	SA-4	130	2	14	21	19	72.00		sa		
2009	SA-4	140	3	13	4	14	41.33	cos	sa		
2009	SA-4	150	3	0	0	0	0.00		sa		
2009	SA-4	160	4	0	0	0	0.00		sa		
2009	SA-4	170	5	0	0	0	0.00		sa, co		
2009	SA-4	180	5	0	0	0	0.00		sa, co		
2009	SA-4	190	5	0	0	0	0.00		sa		
2009	SA-4	200	5	0	0	0	0.00		sa		
2009	SA-5	0	1	0	0	0	0.00	ul	co		
2009	SA-5	10	1	0	0	0	0.00	ul	sa, co		
2009	SA-5	20	1	0	0	0	0.00		sa		
2009	SA-5	30	1	0	0	0	0.00		sa		
2009	SA-5	40	1	0	0	0	0.00	ul, po	sa		
2009	SA-5	50	1	52	0	0	69.33	ul, la	sa	b 49, e 71	small patch at 46', 2' south of transect
2009	SA-5	60	1	64	25	9	130.67	ul, pt	sa, co, sh		
2009	SA-5	70	1	20	21	8	65.33	ul, po, ch, pr	sa, co, sh		
2009	SA-5	80	1	23	29	54	141.33	ul, pr	sa, co	b 73, e 74	
2009	SA-5	90	1	15	0	3	24.00	ul	sa	b 76, e 82	
2009	SA-5	100	2	71	0	39	146.67	ul	sa	b 90, e 96	
2009	SA-5	110	2	16	17	0	44.00	ul	sa	b 100, e 106	
2009	SA-5	120	2	42	12	0	72.00	ul	sa	b 109, e 110	
2009	SA-5	130	2	16	13	0	38.67	ul	sa	b 112, e 142	
2009	SA-5	140	3	32	19	9	80.00	ul, la	sa		
2009	SA-5	150	3	0	0	0	0.00		sa		
2009	SA-5	160	4	0	0	0	0.00	ul, la	sa		
2009	SA-5	170	5	0	0	0	0.00		sa		
2009	SA-5	180	5	0	0	0	0.00		sa		
2009	SA-5	190	5	0	0	0	0.00	ul	sa		
2009	SA-5	200	5	0	0	0	0.00	ul	sa		

Year	Transect	Distance (ft)	Depth Bin	Shoots/(0.25) m^2 2	6	10	Density (m^2)	Macro taxa	Substrate	Eelgrass edge	notes
2009	RA-1	0	1	0	0	0	0.00	ul	co		
2009	RA-1	20	1	0	0	0	0.00	ul, la	co		
2009	RA-1	40	1	0	0	0	0.00	ul	co		
2009	RA-1	60	1	0	0	0	0.00	ul, gr	co		
2009	RA-1	80	1	0	0	0	0.00		sa		
2009	RA-1	100	1	0	0	0	0.00		sa	b 105, e 110	
2009	RA-1	120	1	8	0	0	10.67		sa	b 113, e 117	
2009	RA-1	140	2	0	0	0	0.00		sa	b 119, e 121	
2009	RA-1	160	2	47	0	65	149.33	ul	sa	b 160, e 165	
2009	RA-1	180	2	0	0	77	102.67	ul	sa		
2009	RA-1	200	2	40	65	71	234.67	ul	sa	b 179, e 387	
2009	RA-1	220	2	72	68	41	241.33	ul, la	sa		
2009	RA-1	240	3	61	23	54	184.00	ul, la	sa		
2009	RA-1	260	3	23	16	10	65.33	ul, la	sa		
2009	RA-1	280	4	3	5	5	17.33	ul, la, gr, pt	sa		
2009	RA-1	300	4	0	1	2	4.00	ul, la, ma, pt	sa		
2009	RA-1	320	4	11	16	6	44.00	ul	sa		
2009	RA-1	340	4	5	6	23	45.33	ul, la	sa		
2009	RA-1	360	4	13	14	11	50.67	ul, la	sa		
2009	RA-1	380	4	19	17	20	74.67	ul, la	sa		
2009	RA-1	400	4	0	0	0	0.00		sa		
2009	RA-1	420	5	0	0	0	0.00	gr	sa		
2009	RA-2	0	1	0	0	0	0.00	ul	co		
2009	RA-2	20	1	0	0	0	0.00	ul	co		
2009	RA-2	40	1	0	0	0	0.00	ul	co		
2009	RA-2	60	1	0	0	0	0.00	ul	co		
2009	RA-2	80	1	0	0	0	0.00		sa		
2009	RA-2	100	1	0	0	0	0.00		sa	b 105, e 128	
2009	RA-2	120	1	19	132	127	370.67		sa		
2009	RA-2	140	2	0	0	0	0.00		sa		
2009	RA-2	160	2	0	0	0	0.00		sa	b 162, e 176	
2009	RA-2	180	2	0	0	8	10.67		sa		small patch of 23 shoots, 3x3 @179
2009	RA-2	200	2	73	59	73	273.33	ul	sa	b 186, e 190	
2009	RA-2	220	2	63	85	82	306.67	sm	sa	b 193, e 385	
2009	RA-2	240	3	42	29	39	146.67	ul, gr, pr	sa		
2009	RA-2	260	3	31	23	27	108.00	ul, gr, pr, sm	sa		

Year	Transect	Distance (ft)	Depth Bin	Shoots/(0.25) m^2 2	6	10	Density (m^2)	Macro taxa	Substrate	Eelgrass edge	notes
2009	RA-2	280	4	0	10	11	28.00	ul, gr	sa		
2009	RA-2	300	4	3	1	9	17.33	ul, gr, la, pr, pt	sa		
2009	RA-2	320	4	5	6	4	20.00	ul, gr	sa		
2009	RA-2	340	4	8	11	14	44.00	ul, la	sa		
2009	RA-2	360	4	14	8	19	54.67	ul, po, pt	sa		
2009	RA-2	380	4	8	6	19	44.00	ul	sa		
2009	RA-2	400	4	0	0	0	0.00	ul	sa		
2009	RA-2	420	5	0	0	0	0.00		sa		
2009	RA-3	0	1	0	0	0	0.00	ul	co		
2009	RA-3	20	1	0	0	0	0.00	ul, ch	co		
2009	RA-3	40	1	0	0	0	0.00	ul	co, sh		
2009	RA-3	60	1	0	0	0	0.00	ul	sa, co, sh		
2009	RA-3	80	1	0	0	0	0.00		sa		
2009	RA-3	100	1	0	0	0	0.00		sa	b 105, e 112	
2009	RA-3	120	1	237	191	223	868.00		sa	b 115, e 133	
2009	RA-3	140	2	0	0	0	0.00		sa		
2009	RA-3	160	2	0	0	0	0.00		sa	b 155, e 156	
2009	RA-3	180	2	72	125	179	501.33		sa	b 171, e 183	
2009	RA-3	200	2	106	119	80	406.67		sa	b 195, e 282	
2009	RA-3	220	2	58	97	53	277.33	ul	sa		
2009	RA-3	240	3	34	56	45	180.00	ul	sa		
2009	RA-3	260	3	13	13	1	36.00	ul, po, pr, gr, sm	sa		
2009	RA-3	280	4	0	7	9	21.33	la, pr, gr, ce	sa	b 289, e 293	
2009	RA-3	300	4	3	0	4	9.33	ul, ma, ce, pr, gr	sa	b 300, e 386	
2009	RA-3	320	4	8	27	25	80.00	ul, ce	sa		
2009	RA-3	340	4	13	9	17	52.00	ul, la	sa		
2009	RA-3	360	4	5	27	13	60.00	ul, la	sa		
2009	RA-3	380	4	32	6	8	61.33	ul, la	sa		
2009	RA-3	400	4	0	0	0	0.00		sa		
2009	RA-3	420	5	0	0	0	0.00		sa		
2009	RA-4	0	1	0	0	0	0.00	ul	co		
2009	RA-4	20	1	0	0	0	0.00	ul, ch	co		
2009	RA-4	40	1	0	0	0	0.00	ul, ch	co		

Year	Transect	Distance (ft)	Depth Bin	Shoots/(0.25) m^2 2	6	10	Density (m^2)	Macro taxa	Substrate	Eelgrass edge	notes
2009	RA-4	60	1	0	0	0	0.00	ul, ch, po, co, gr	co		
2009	RA-4	80	1	0	0	0	0.00	ul	sa		
2009	RA-4	100	1	0	0	0	0.00		sa		
2009	RA-4	120	1	164	121	142	569.33		sa	b 106, e 141	
2009	RA-4	140	2	0	43	59	136.00	ul	sa		
2009	RA-4	160	2	0	0	0	0.00		sa	b 169, e 258	
2009	RA-4	180	2	151	144	168	617.33	ul	sa		
2009	RA-4	200	2	163	39	86	384.00	ul, gr	sa		
2009	RA-4	220	2	78	84	99	348.00	ul	sa		
2009	RA-4	240	3	53	47	38	184.00	ul, la, sm	sa		
2009	RA-4	260	3	0	4	0	5.33	ul, ma, po, pr, pt, gr, co	sa, co		concrete piece
2009	RA-4	280	4	0	0	0	0.00	ul, pr, la, gr, pr	sa, co	b 273, e 389	
2009	RA-4	300	4	1	0	12	17.33	ul, gr, la, pr, pt	sa		
2009	RA-4	320	4	8	3	12	30.67	ul, gr	sa		
2009	RA-4	340	4	27	16	33	101.33	ch, pt	sa		
2009	RA-4	360	4	11	32	20	84.00	la, pr, gr	sa		
2009	RA-4	380	4	9	39	32	106.67	la, po	sa		
2009	RA-4	400	4	0	0	0	0.00		sa		
2009	RA-4	420	5	0	0	0	0.00	la, gr	sa		
2009	RA-5	0	1	0	0	0	0.00	ul, ch	gr, co, sh		
2009	RA-5	20	1	0	0	0	0.00	ul, ch, ma	gr, co, sh		
2009	RA-5	40	1	0	0	0	0.00	ul, ch	gr, co, sh		
2009	RA-5	60	1	0	0	0	0.00	ul, ch, unk, gr	sa, gr, co, sh		
2009	RA-5	80	1	0	0	0	0.00	ul	sa, gr, co		
2009	RA-5	100	1	0	0	0	0.00		sa		
2009	RA-5	120	1	24	98	8	173.33	ul, ma, pr	sa, gr	b 111, e 147	
2009	RA-5	140	2	56	75	68	265.33	ul, gr, pr	sa, gr	b 152, e 155	
2009	RA-5	160	2	0	0	0	0.00		sa, gr		
2009	RA-5	180	2	0	0	0	0.00		sa		
2009	RA-5	200	2	92	83	86	348.00		sa	b 185, e 269	
2009	RA-5	220	2	72	76	71	292.00	sm	sa		
2009	RA-5	240	3	35	51	41	169.33	sm	sa		
2009	RA-5	260	3	7	22	12	54.67	ul, sm, pr,	sa, gr		

Year	Transect	Distance (ft)	Depth Bin	Shoots/(0.25) m^2 2	6	10	Density (m^2)	Macro taxa	Substrate	Eelgrass edge	notes
								gr, ma			
2009	RA-5	280	4	0	2	0	2.67	pr, gr, ul, ma, la	sa, sh	b 275, e 279	
2009	RA-5	300	4	0	0	0	0.00	fa, ch,la, gr, pr, ul, grp	sa, sh		
2009	RA-5	320	4	15	9	15	52.00	ul, grp, sm, mr	sa	b 303, e 394	
2009	RA-5	340	4	14	14	24	69.33	sm, ul, grp	sa		
2009	RA-5	360	4	16	12	14	56.00	ma	sa		
2009	RA-5	380	4	28	33	15	101.33	fa, sm	sa		
2009	RA-5	400	4	0	0	0	0.00		sa		
2009	RA-5	420	5	0	0	0	0.00		sa		